Indirect and Semi-Direct Aerosol Campaign (ISDAC)
The Influence of Arctic Aerosol on Clouds

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ARM AVP: Beat Schmid, Greg McFarquhar, Jason Tomlinson, John Hubbe, Debbie Ronfeld

In situ measurements: Sarah Brooks, Don Collins, Dan Cziczo, Manvendra Dubey, Mary Gilles, Ismail Gultepe, Greg Kok, Alexei Korolev, Alex Laskin, Paul Lawson, Peter Liu, Claudio Mazzoleni, Ann-Marie Macdonald, Greg McFarquhar, Ryan Moffet, Walter Strapp, Alla Zelenyuk

Retrievals: Connor Flynn, Dan Lubin, David Mitchell, Rich Ferrare, Matthew Shupe, David Turner, Mengistu Wolde

Modeling: Mikhail Ovtchinnikov, Shaocheng Xie, Xiaohong Liu

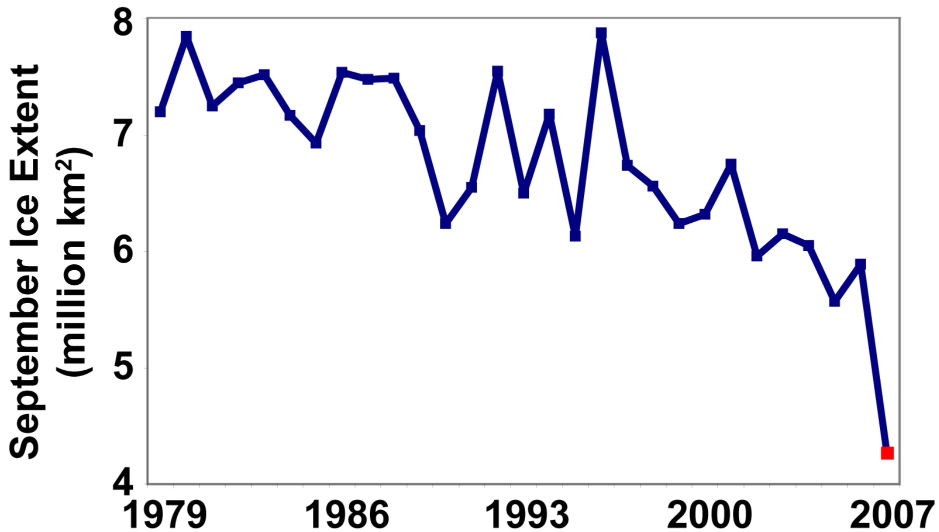
Barrow, Alaska April 2008

ARM

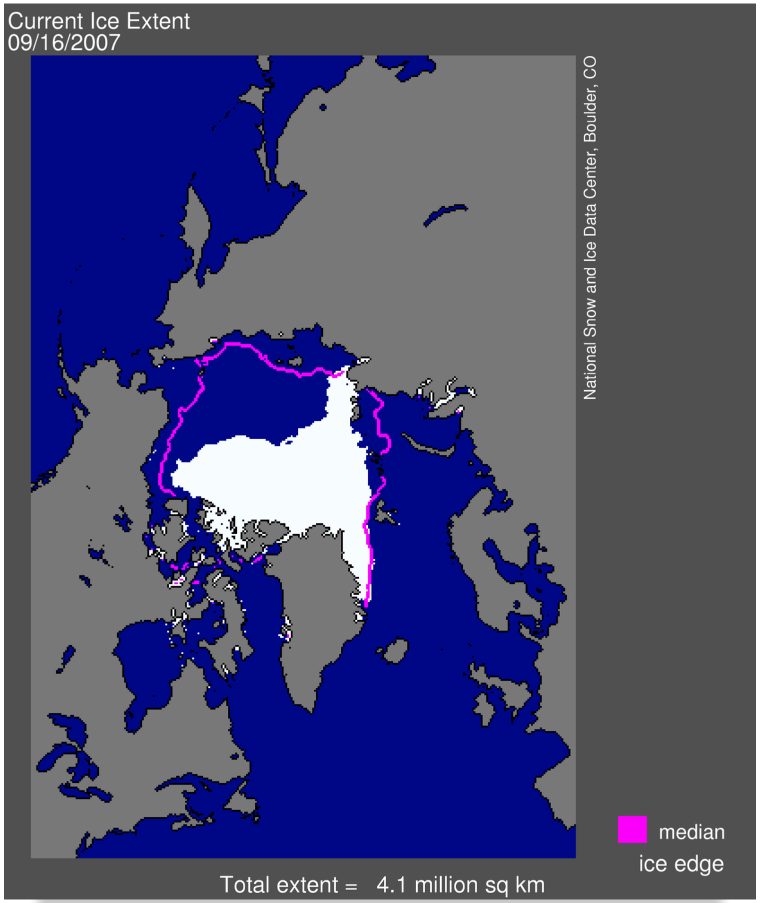
http://acrf-campaign.arm.gov/isdac/

ASP

2007 Record Minimum Arctic Sea Ice Extent



September Arctic sea ice extent
(credit: NSIDC)



Credit: NSIDC

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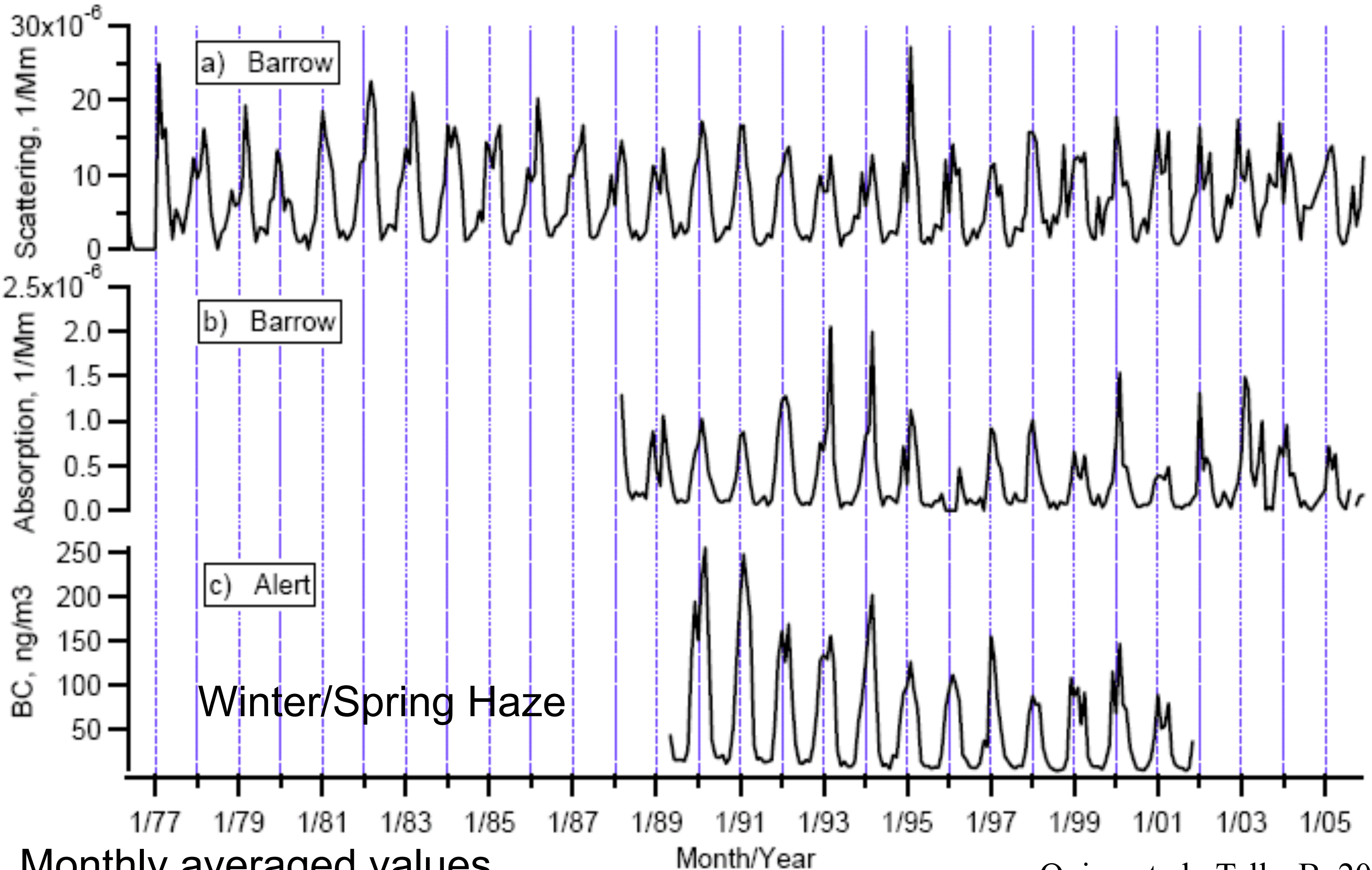
Seasonality of Arctic Aerosol

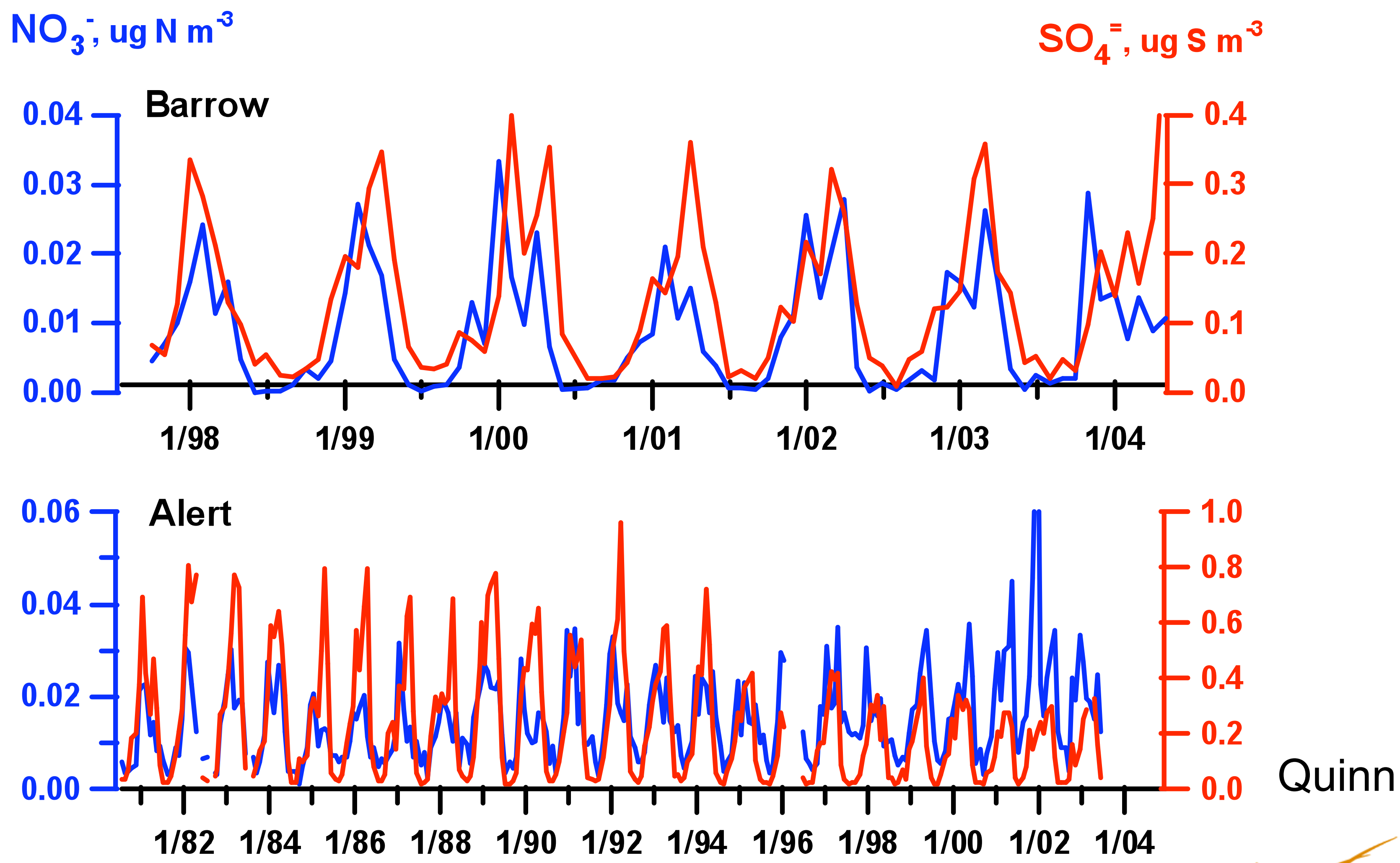


Monthly averaged values

Quinn et al., TellusB, 2007.

Seasonality of Arctic Haze

Winter/Spring Increase in Aerosol Nitrate and Sulfate



Sources: **Diesel and gasoline engines** **Coal fired power plants**

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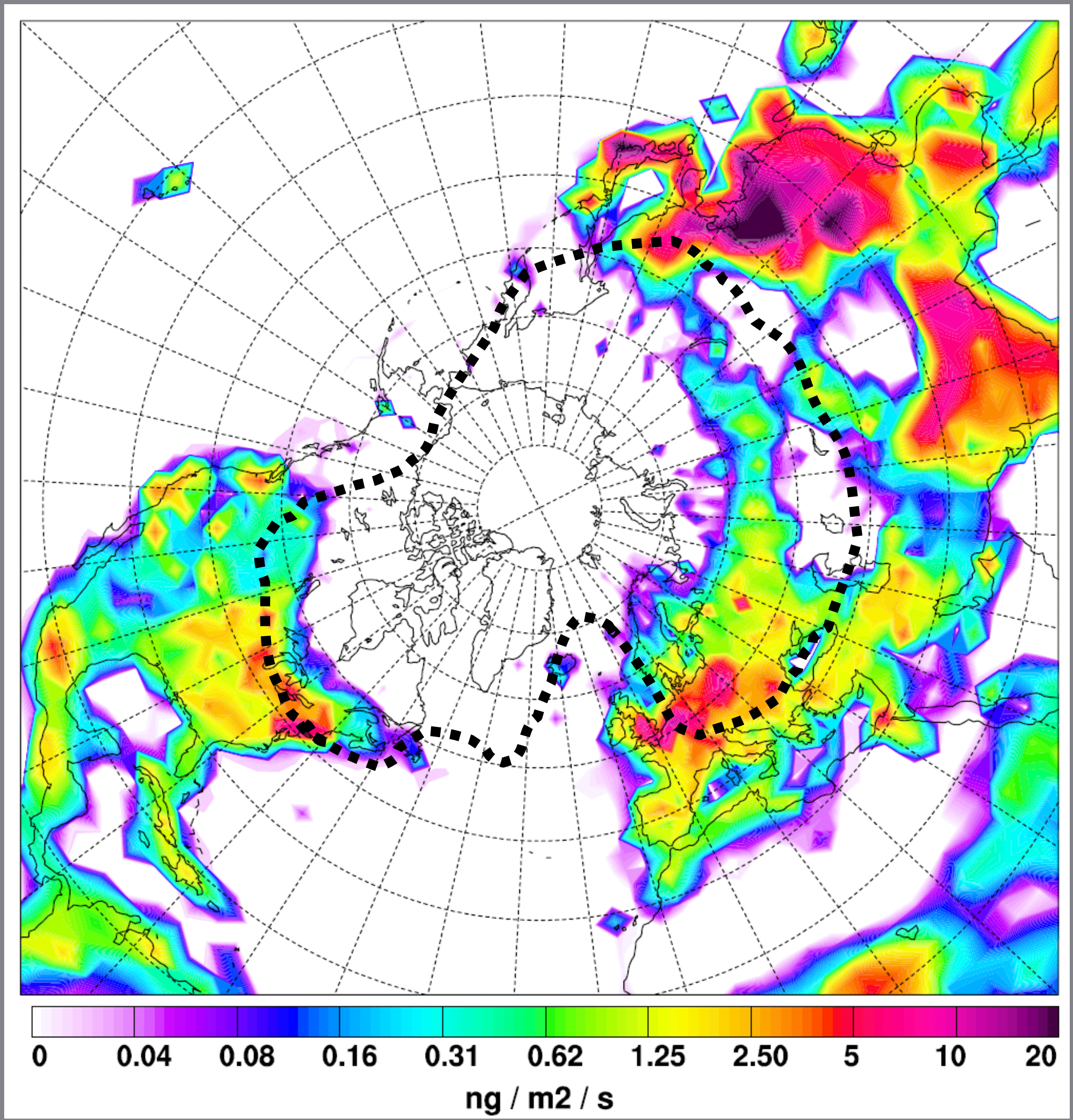

Anthropogenic sources of soot (industrial and biofuel)

Sources in northern Europe and NE China are consistently within or near the mean position of the Arctic front.

Stohl et al., 2006

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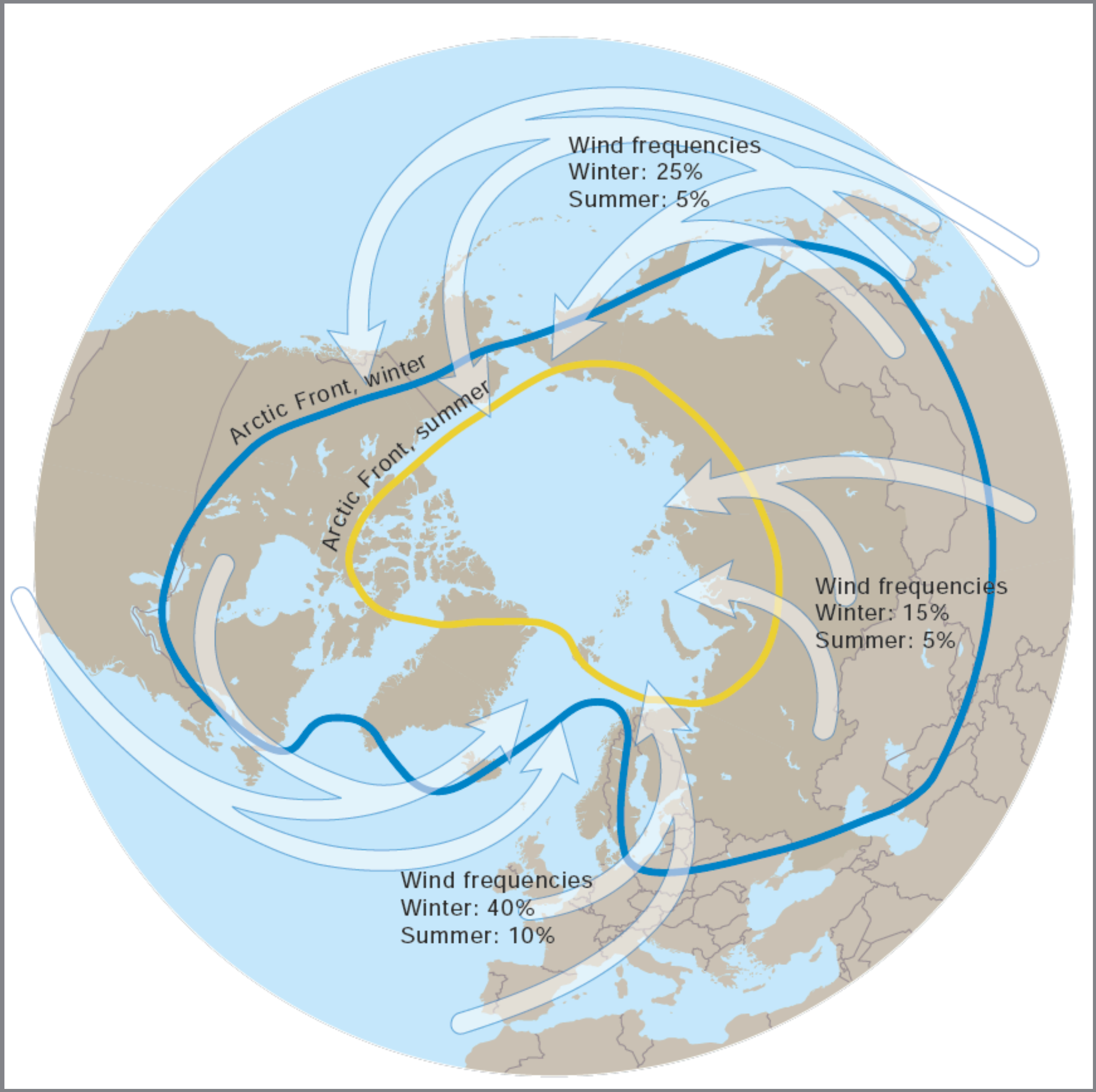

Sources for surface haze generally lie within the Arctic front

Layers aloft may have sources further south (if they can survive cross-front processes)

Arctic Monitoring and Assessment Programme, 2006

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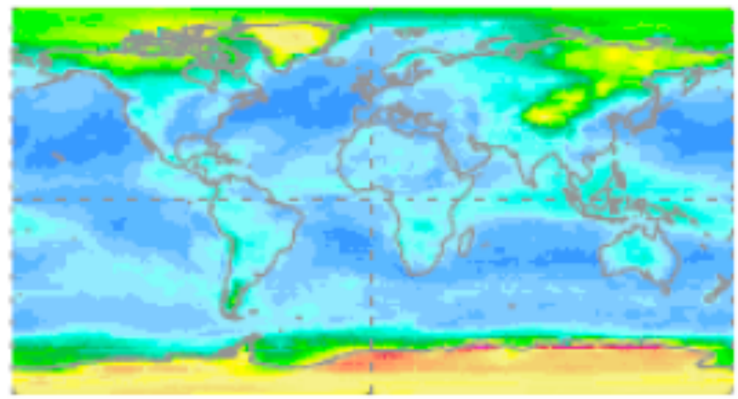
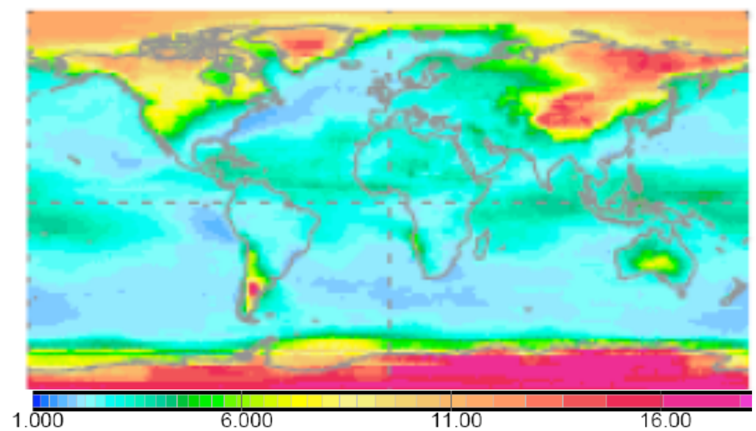
Aerosol Models Have Particular Trouble Simulating Aerosol Beyond the Polar Front

- Most relative uncertainty in simulated AOD/mass poles.
- Arctic aerosol sources primarily from midlatitudes.
- Uncertainty in transport treatment unlikely to cause x10-uncertainty.
- Large uncertainty could be from treatment of cloud scavenging.

Max/Min of Central 2/3 of !6 Models



Aerosol Column Mass



Kinne et al., An AeroCom initial assessment. *Atmos. Chem. & Phys.*, 2006.

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Key ISDAC Issues

1. How do properties of the Arctic aerosol during April differ from those measured by M-PACE during October?
2. To what extent do different properties of arctic aerosol during April produce differences in microphysical and macrophysical properties of clouds and the surface energy balance?
3. How well can cloud models and parameterizations used in climate models simulate the sensitivity of Arctic clouds and the surface energy budget to the differences in aerosol between April and October?
4. How well can long-term surface-based measurements at the ACRF Barrow site provide retrievals of aerosol, cloud, precipitation and radiative heating in the Arctic?

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ISDAC Observations (~42 instruments)

- temperature
- dew-point temperature
- total particle concentration
- aerosol size distribution (0.01-3 μm)
- size-resolved aerosol hygroscopicity (0.02-0.6 μm)
- cloud condensation nuclei concentration
- ice nuclei concentration
- single particle size and composition
- optical scattering by aerosol (neph/3-λ PA
- optical absorption by aerosol (PSAP/3-λ PA)
- vertical velocity
- cloud liquid water content
- total cloud water content
- cloud particle size distribution (0.5-2500 μm)
- cloud particle image (15-2500 μm)
- cloud extinction

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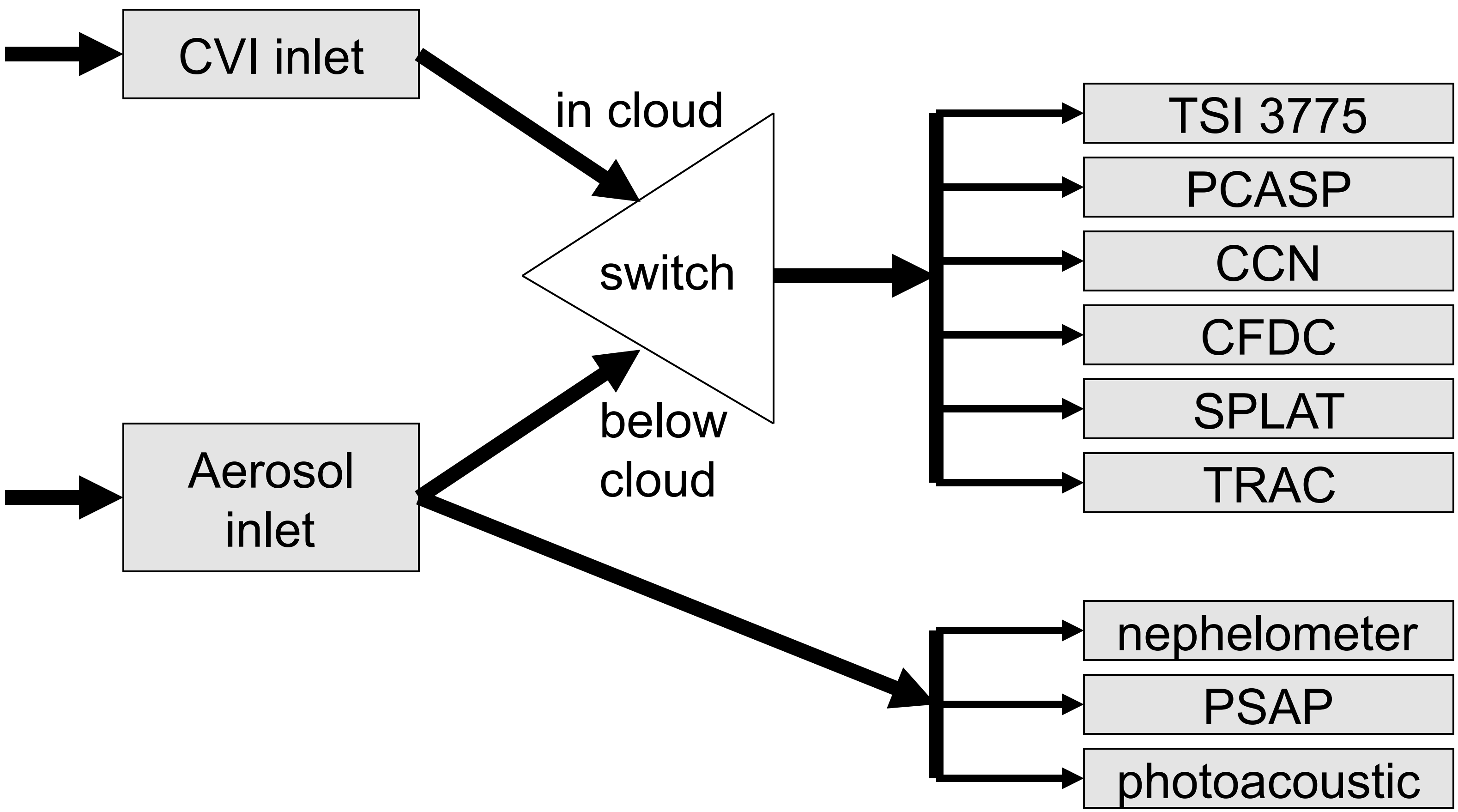
Aerosol Instrument Configuration



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Applications

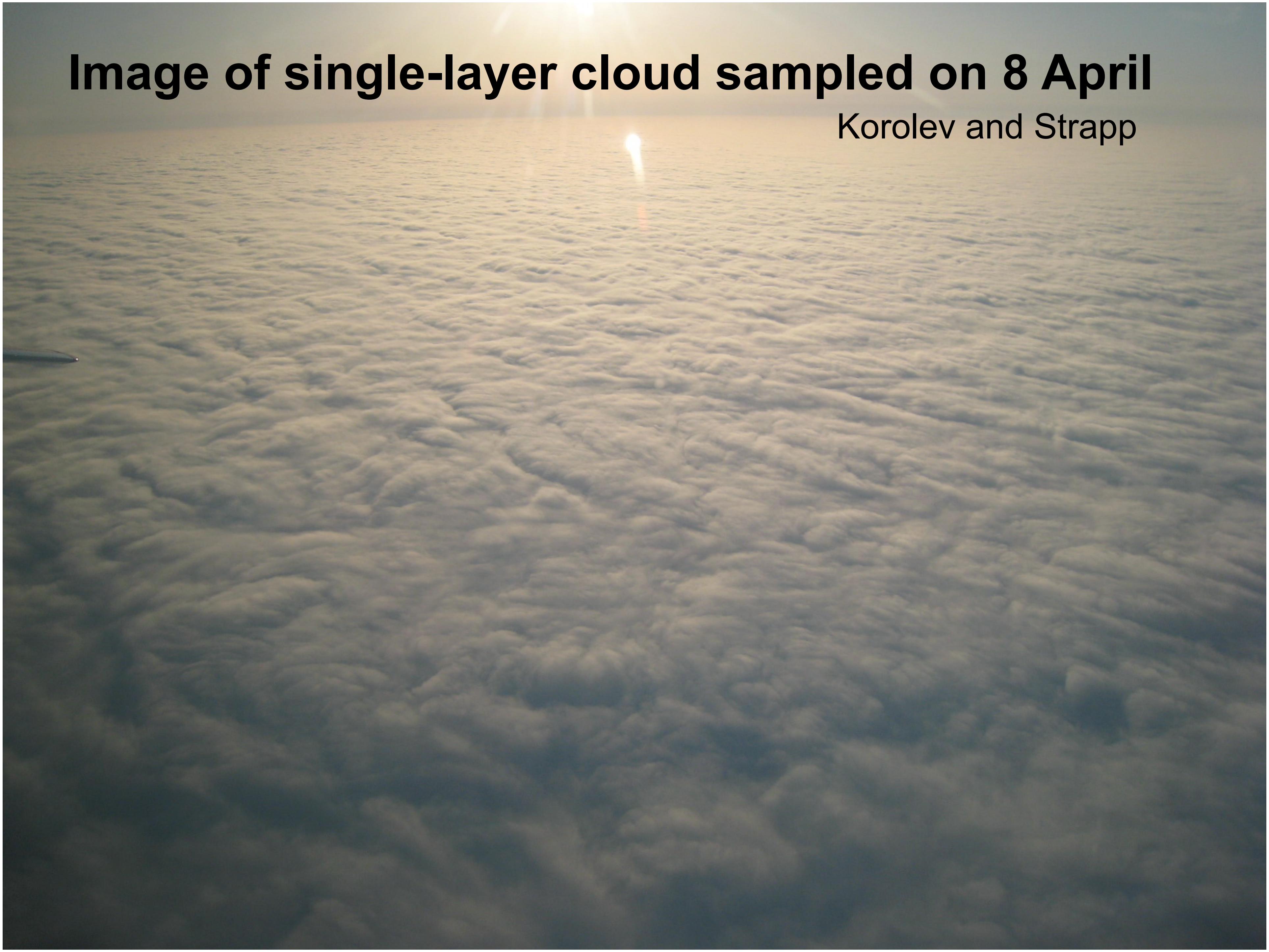
- CCN closure
- Droplet number closure
- Aerosol extinction closure
- Cloud extinction closure
- Cloud water closure
- Cloud modeling
- Semi-direct effect
- Crystal nucleation
- Aerosol extinction retrieval
- CCN retrieval
- MMCR retrievals
- MWR retrievals
- AERI retrievals
- ASD retrievals

ISDAC Flights Summary

- 27 project sorties representing 103.6 hours of data on 12 different flight days
- Golden days with single-layer stratocumulus on 8 and 26 April when 3 sorties flown
- Heavily polluted day on 19 April
- Instrument performance for most part excellent

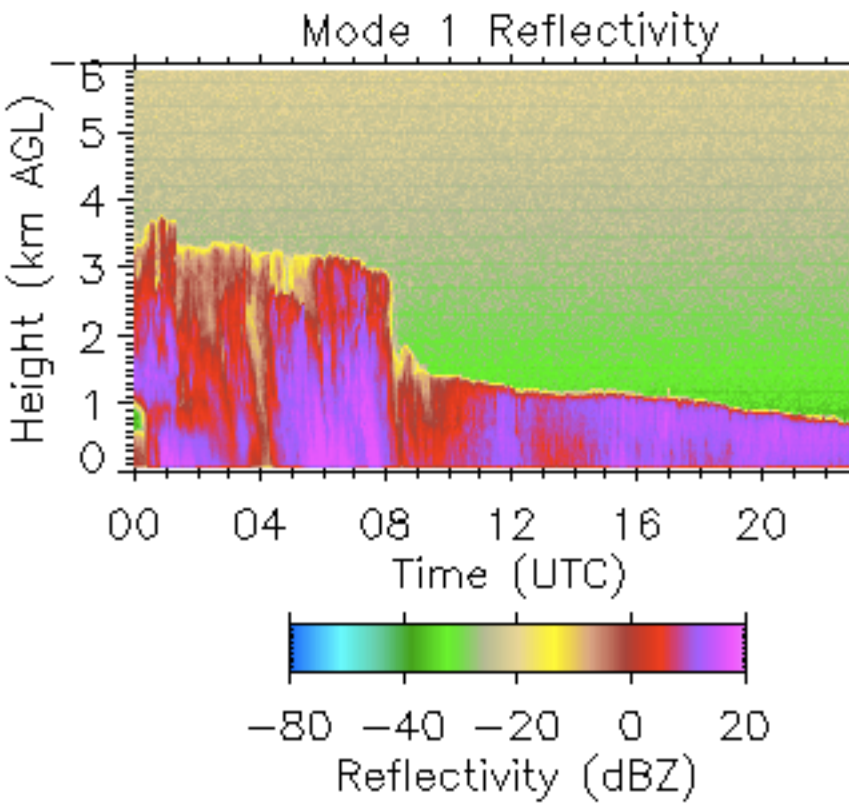
Image of single-layer cloud sampled on 8 April

Korolev and Strapp

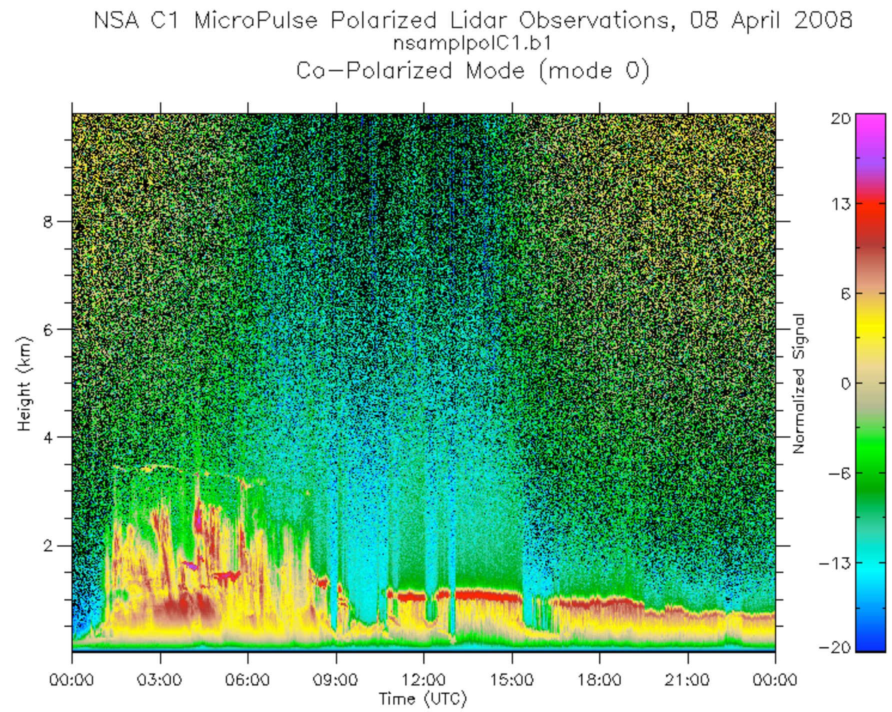


April 8

Cloud Radar Reflectivity



Micropulse Lidar Co-Polarized Mode



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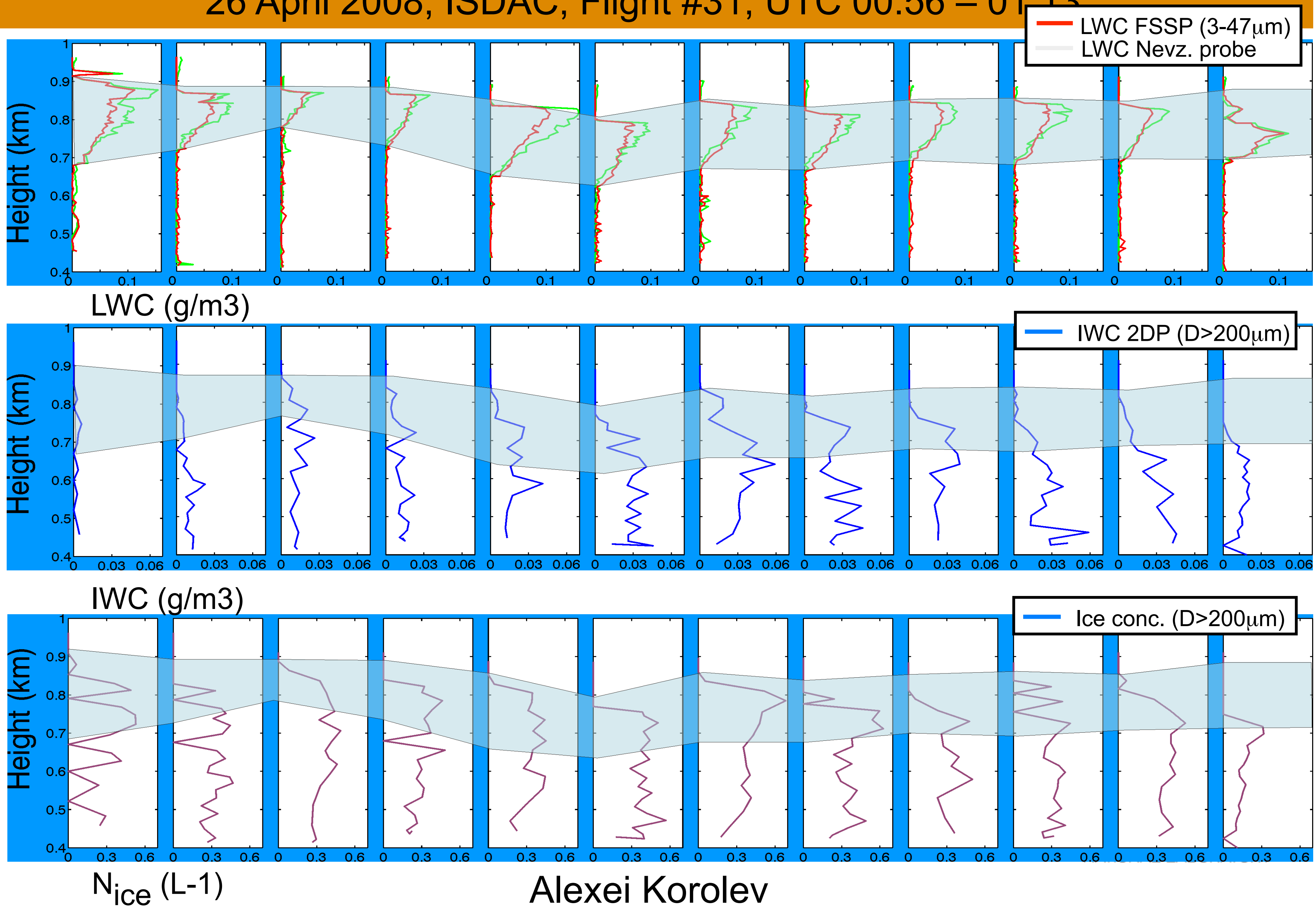
Bulk cloud properties

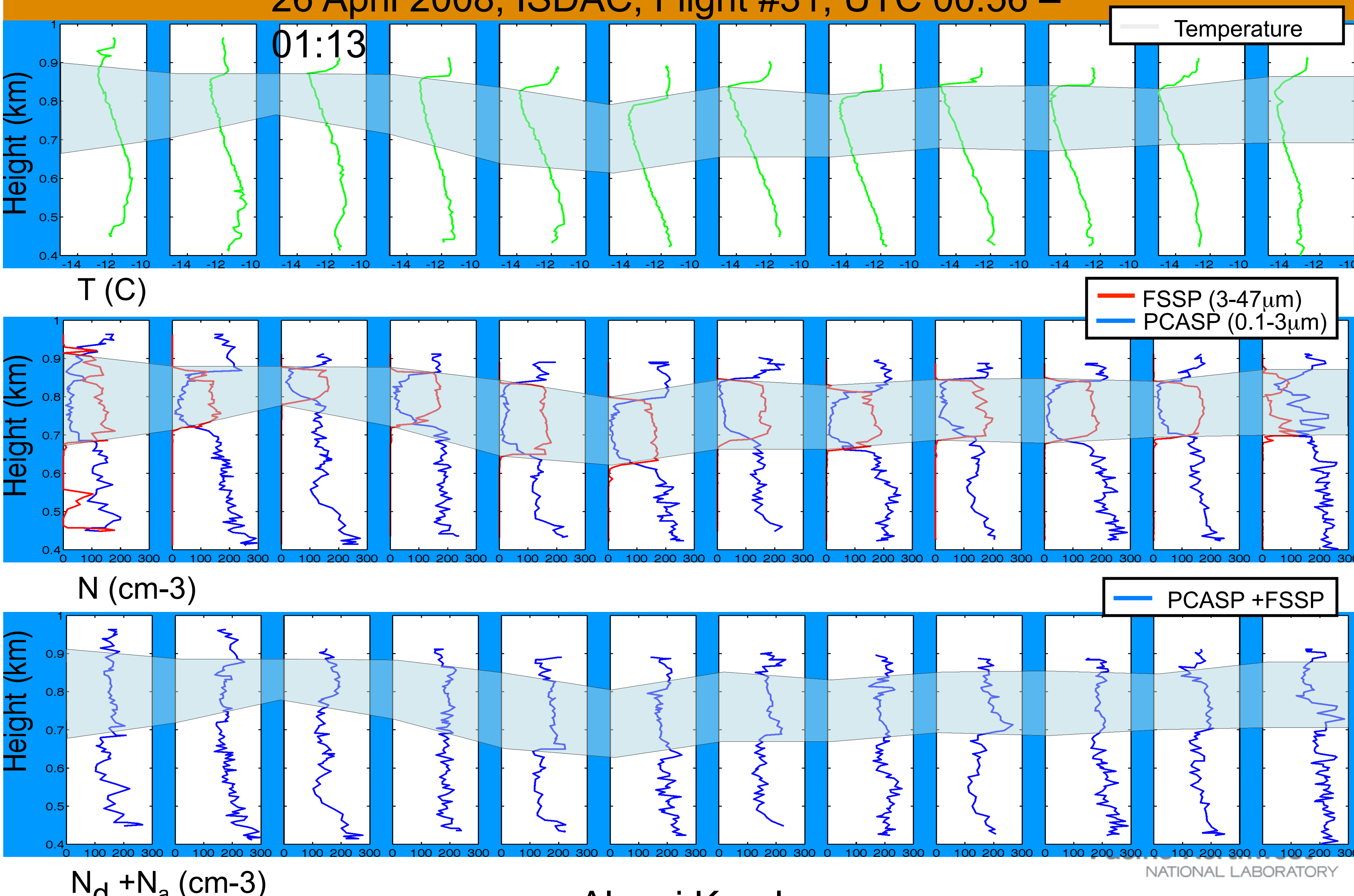
26 April 2008, ISDAC, Flight #31, UTC 00:56 – 01:13



Alexei Korolev

Droplet and Aerosol Number

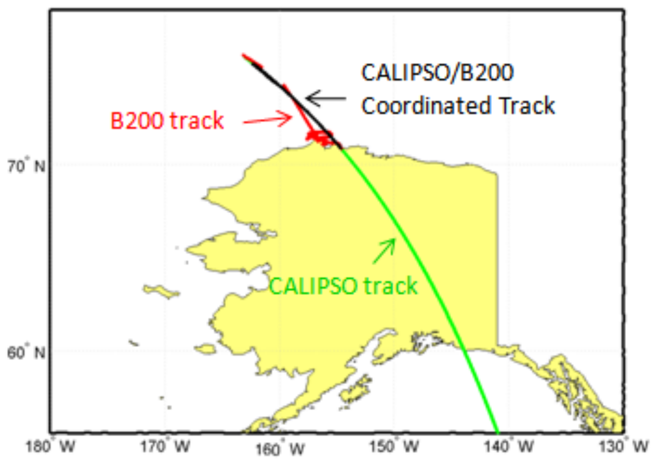
26 April 2008, ISDAC, Flight #31, UTC 00:56 – 01:13

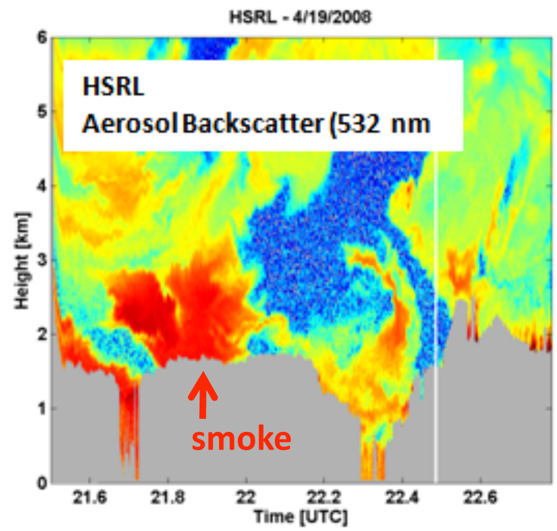


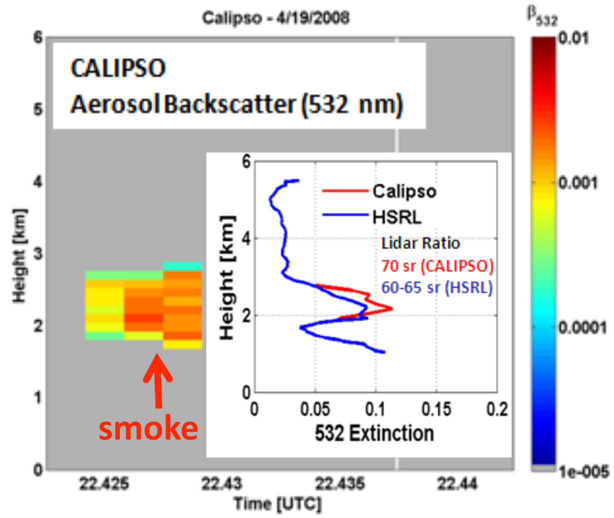
Alexei Korolev

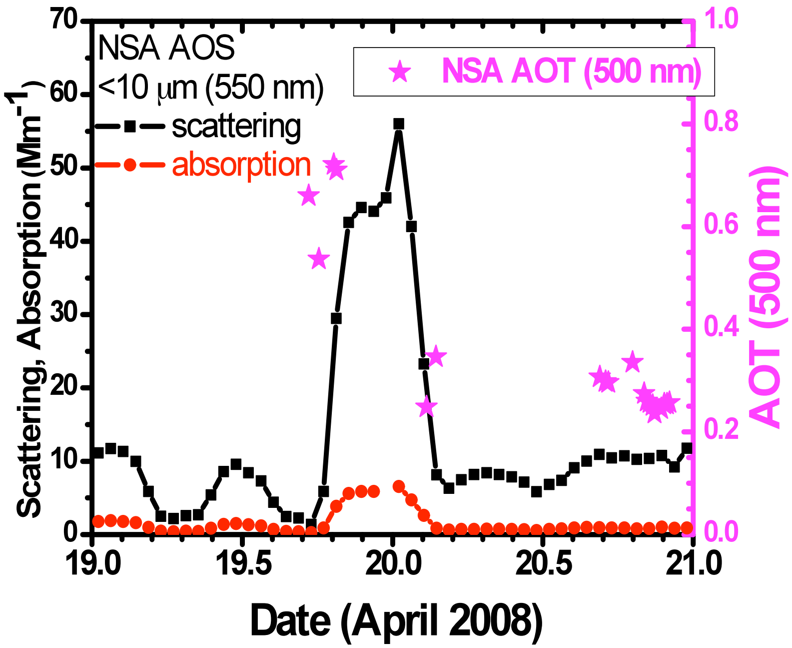
CALIPSO Validation During ARCTAS/ISDAC
Example – April 19 – Siberian Forest Fire Smoke

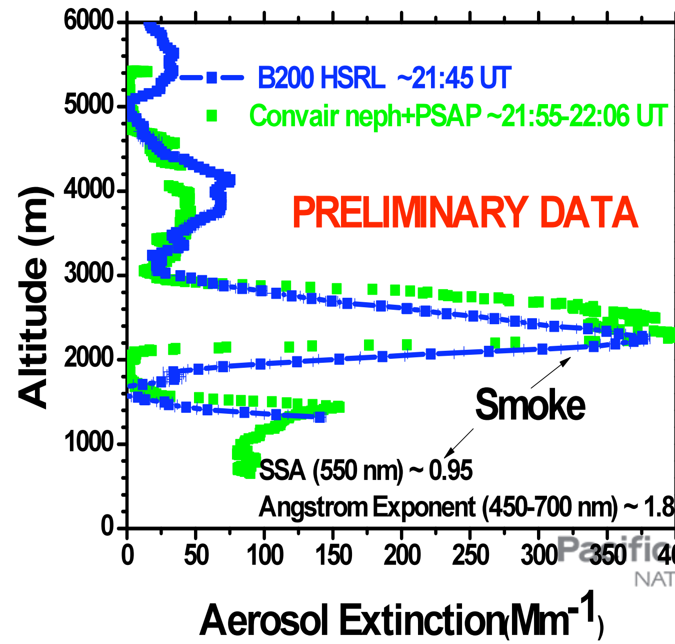
Rich Ferrare et al.











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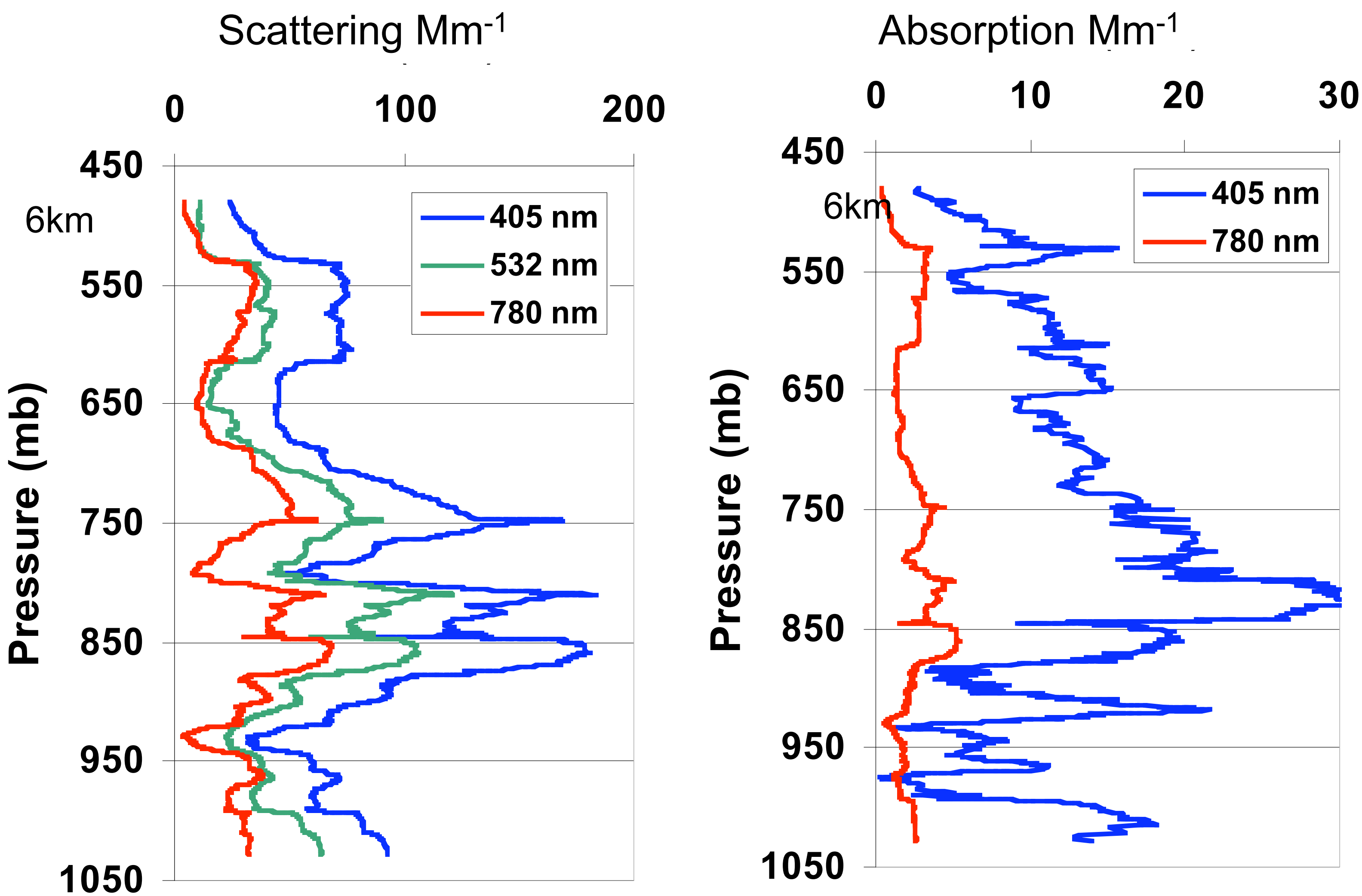
Los Alamos 3-Laser Photoacoustic Absorption and Scattering 405, 532, 781nm



Manvendra Dubey

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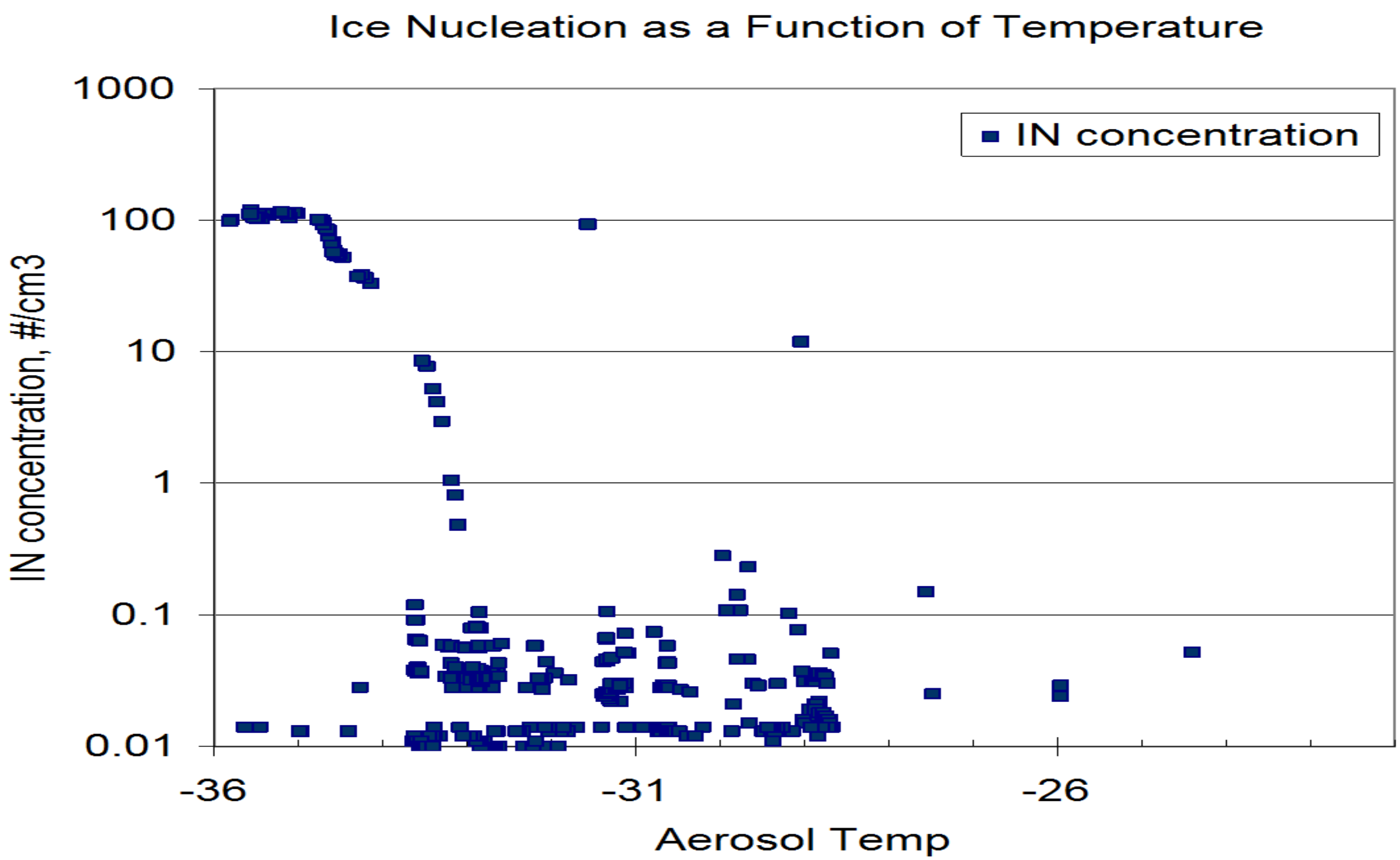
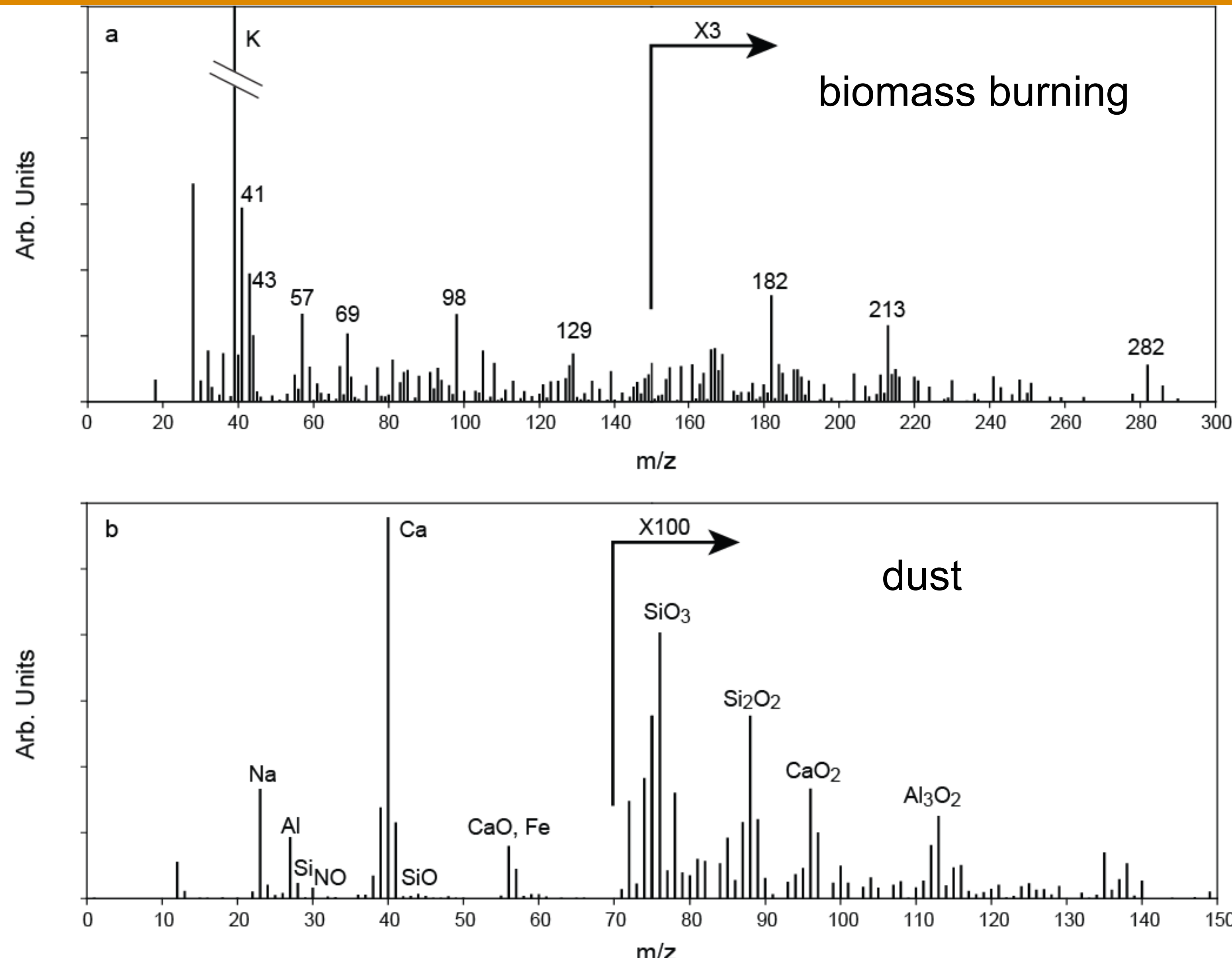
IN measurements

Sarah Brooks

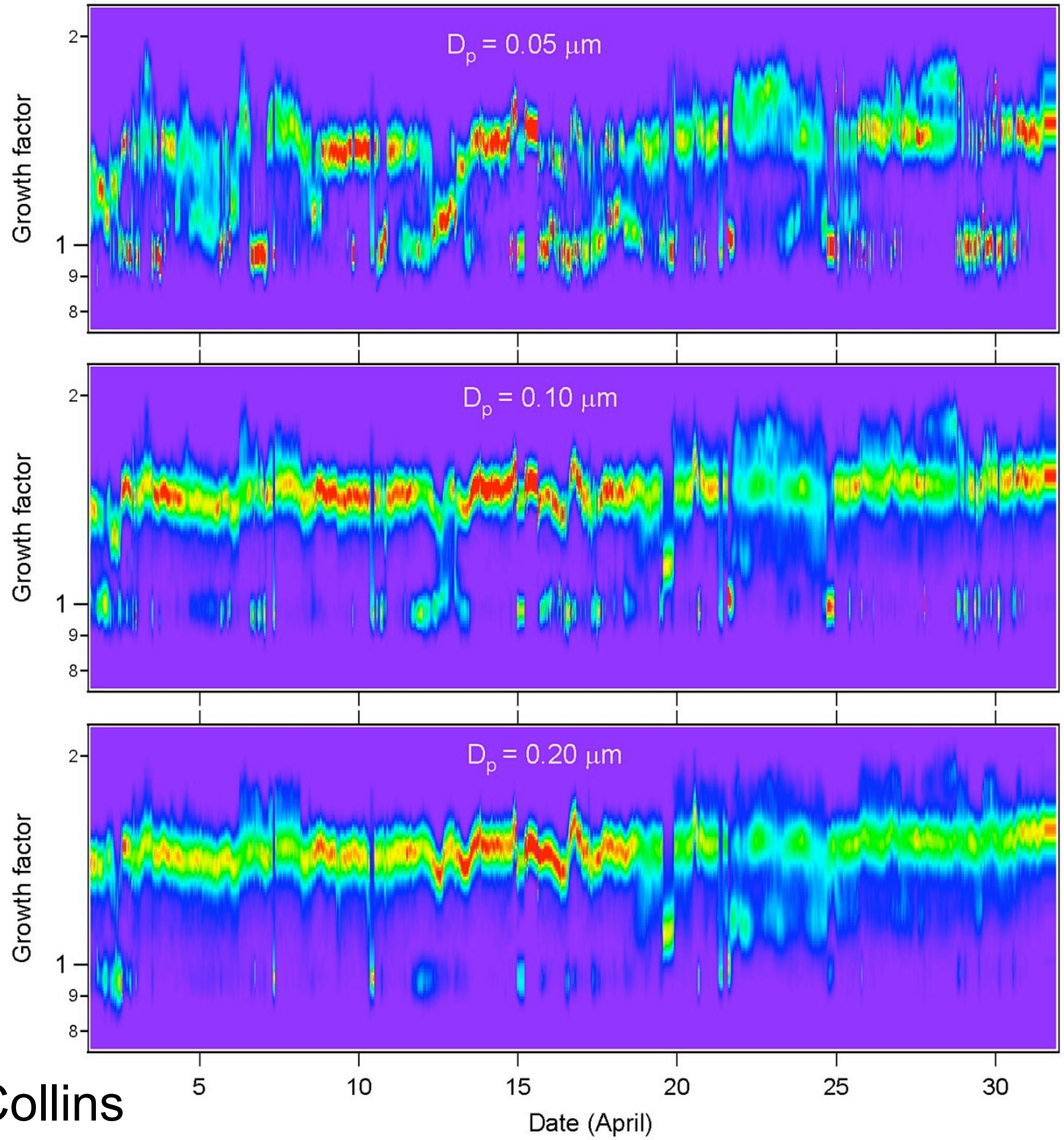


Aerosol composition from mass spectra



Alla Zelenyuk

Aerosol Hygroscopicity



Don Collins

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Cloud Microphysics Measurements

- **Size distributions:**
  - Forward scattering probes (1 < D < 50 μm)
  - Optical array probes (50 μm < D < 10 mm)
- **High-resolution images of hydrometeors**
- **Bulk parameters**
  - Bulk liquid water and total water
  - Bulk extinction
  - Flag for presence of supercooled water
- **Redundancy key to microphysical measurements**
  - assess consistency & performance of multiple probes through closure tests (extinction & mass)
  - address question of crystal shattering and measurement of small crystals

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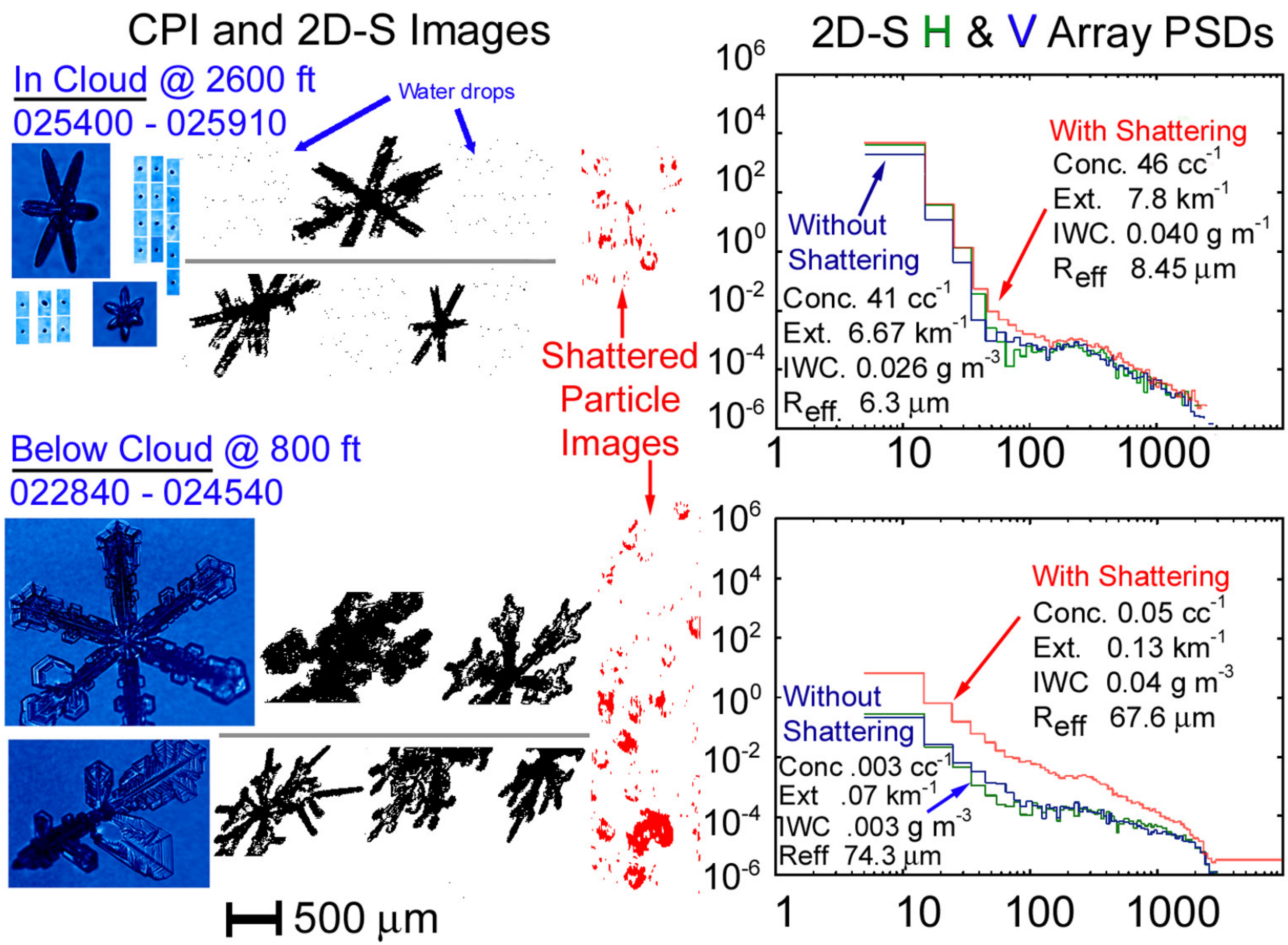
Microphysical Properties with and Without Shattering (4-26-08)



Lawson et al.

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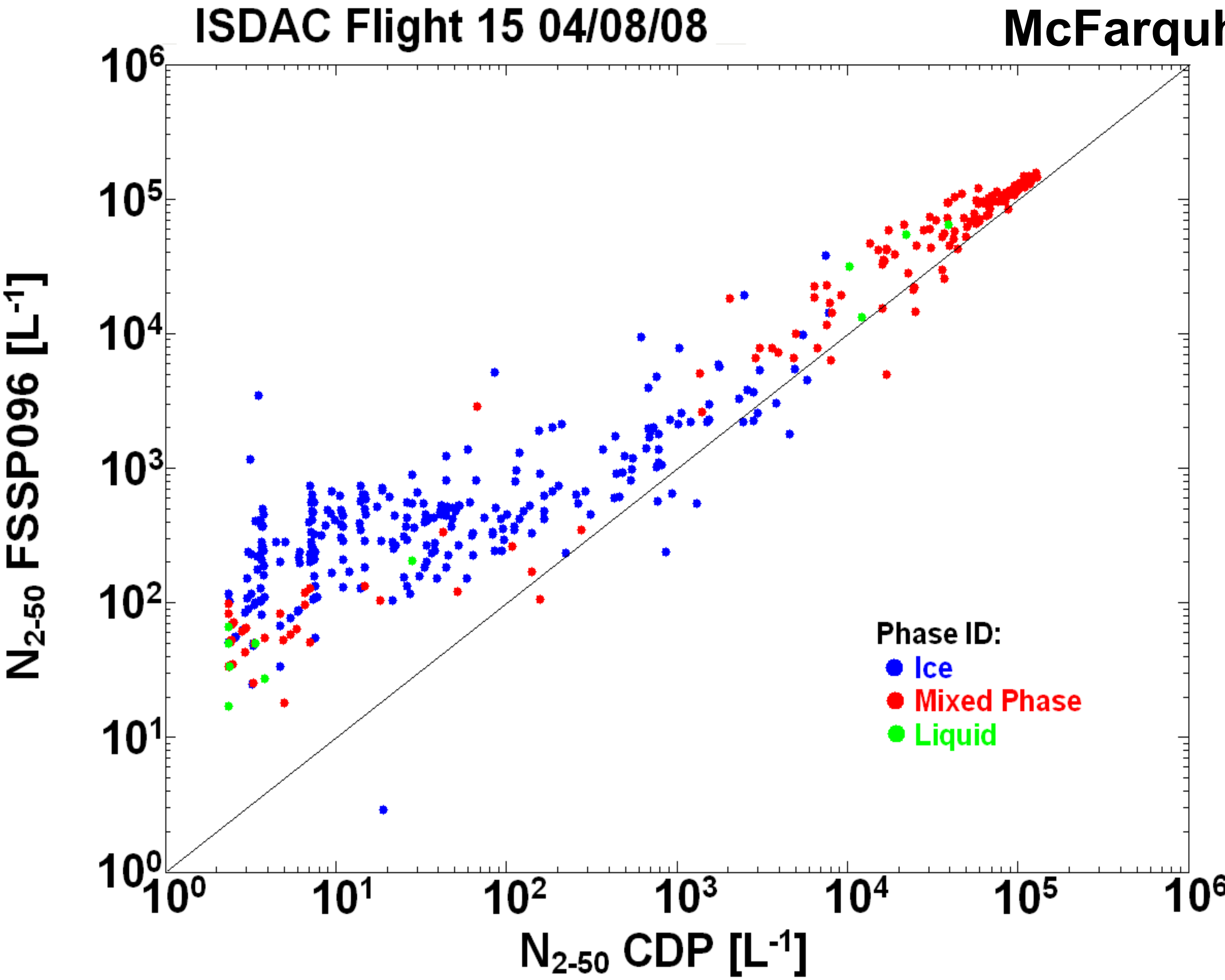
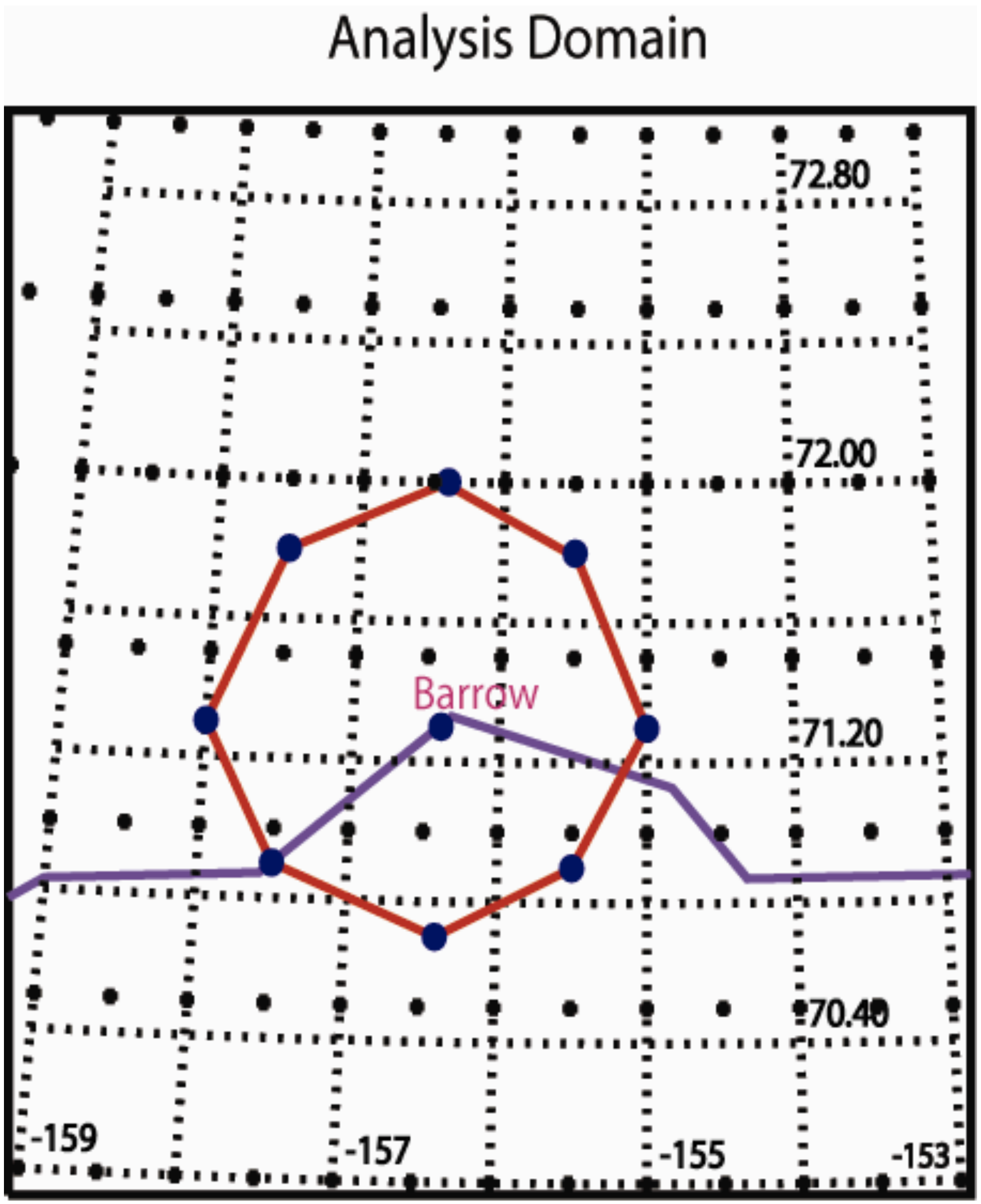
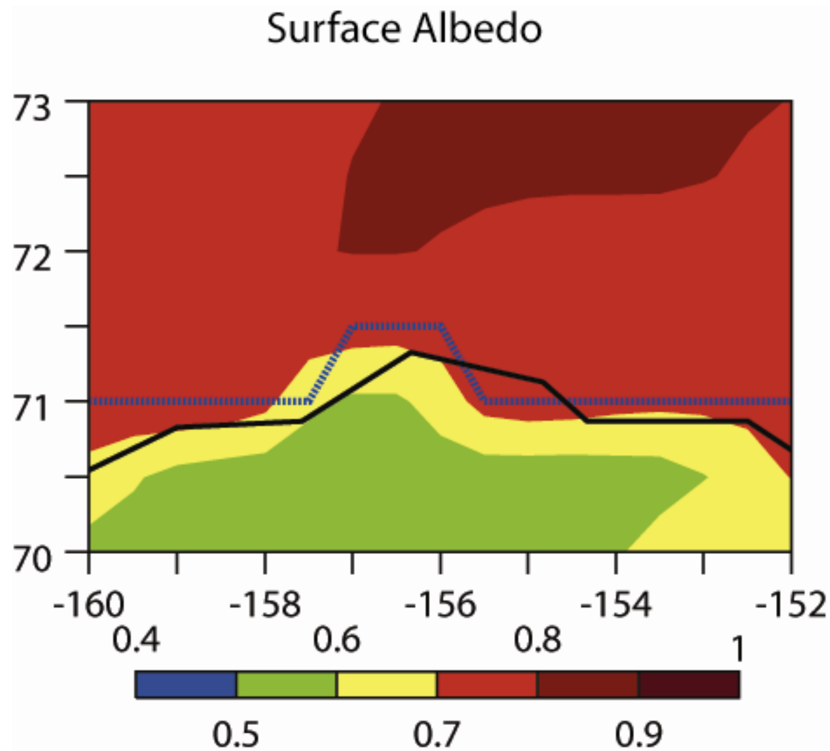
Crystal Shattering Issue

McFarquhar et al.



Modeling ISDAC Clouds





Shaocheng Xie

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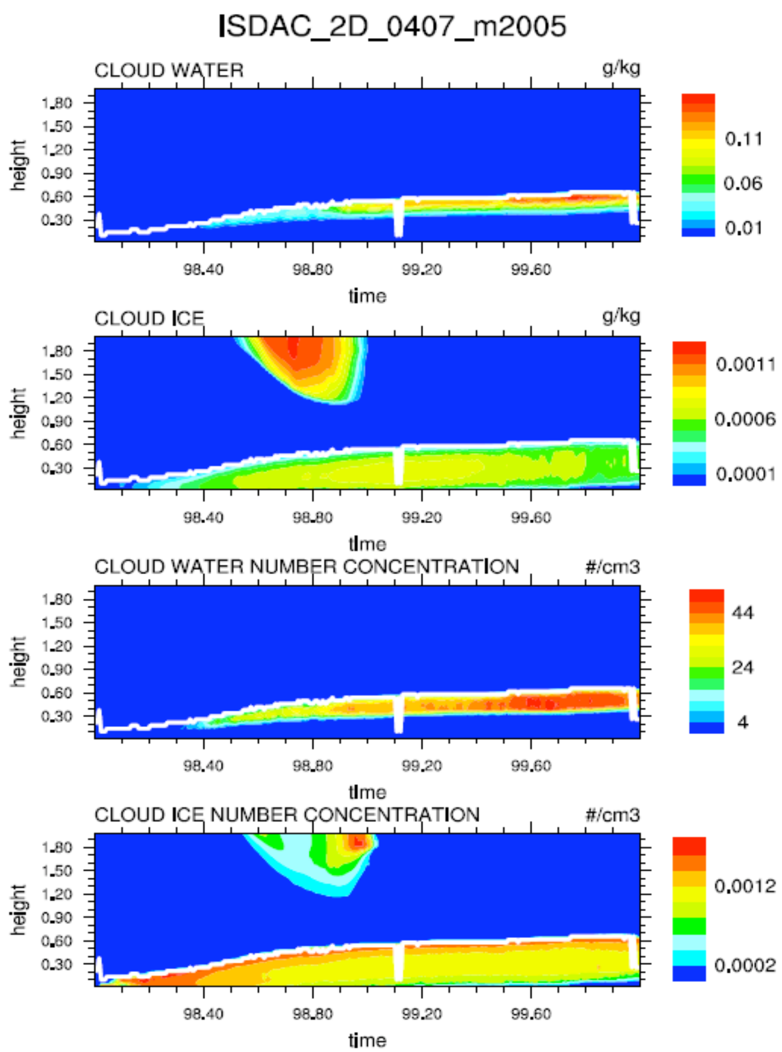
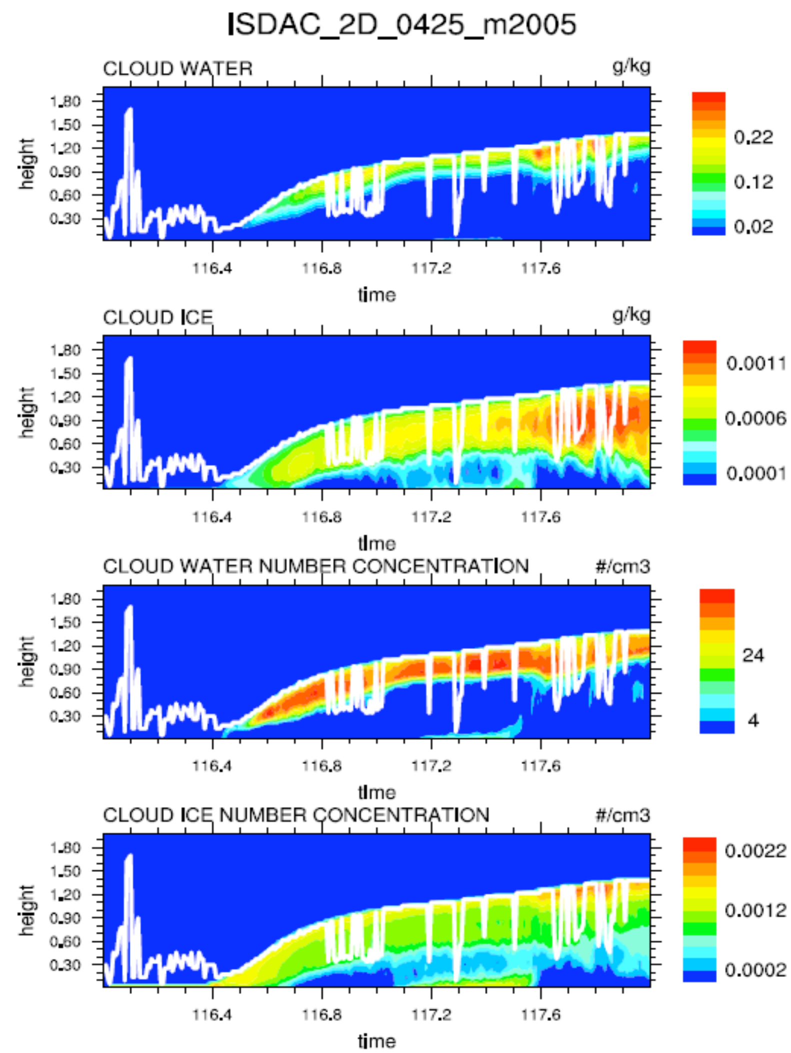
Cloud simulation with Morrison microphysics

Mikhail Ovtchinnikov

April 8

April 26





M-PACE vs ISDAC

- ISDAC and M-PACE boundary conditions are very different because of the much more extensive ocean water during M-PACE.
- Separate influence of different boundary conditions from different aerosol by performing four simulations:
  - M-PACE aerosol and boundary conditions
  - M-PACE aerosol and ISDAC boundary conditions
  - ISDAC aerosol and M-PACE boundary conditions
  - ISDAC aerosol and boundary conditions.

ISDAC Summary

- Data from comprehensive (~42) state of the art instruments link aerosol composition, cloud microphysics and optical properties for process level model development of Arctic clouds.
- Very rich aerosol/cloud data set collected, including (but not limited to) golden cases of single-layer stratus.
- Data is being processed to provide both cloud model input (aerosol) and model validation (cloud).
- An ISDAC meeting was held in November 2008.
- An ISDAC session will be held at the next ARM Science Team meeting.

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